Fisheries and Oceans Canada | Pêches et Océans Canada
Science | Sciences
Central and Arctic Region
Canadian Science Advisory Secretariat
Science Advisory Report 2012/065

ASSESSMENT OF DOLLY VARDEN FROM THE BIG FISH RIVER, NT 2009-2011

Dolly Varden from the Big Fish River (Salvelinus malma malma).
Photo by Colin Gallagher

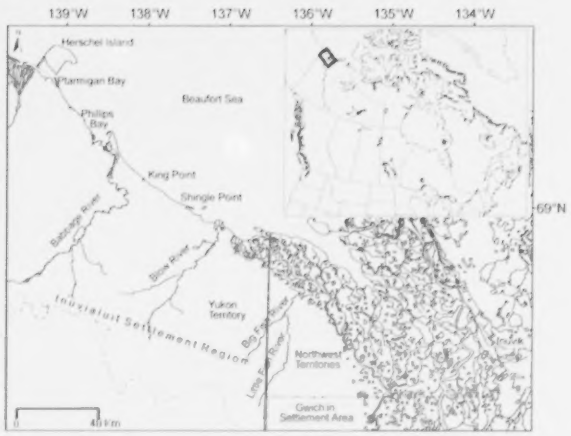

Figure 1. Location of the Big Fish and Little Fish rivers in the Northwest Territories. Insert shows location of study area in Canada.

Context

Populations of anadromous Dolly Varden (Salvelinus malma) in the Canadian Arctic are situated in both the Gwich'in Settlement Area (GSA) and the Inuvialuit Settlement Region (ISR), and are important for the subsistence of Gwich'in and Inuvialuit peoples. Due to declines in abundance of Dolly Varden from the Big Fish River, Northwest Territories (situated in the ISR) all fishing activity was prohibited in the river proper, including its tributary, the Little Fish River, and areas adjacent to its mouth in the Mackenzie River Delta in 1987. Currently, Dolly Varden from the Big Fish River are only harvested in a mixed-stock-fishery along the Beaufort Sea coast, mainly at Shingle Point, Yukon Territory. Subsequent assessments (2002 and 2008) have demonstrated that population abundance has remained low and it is unclear whether this is a result of harvesting, changes in overwintering habitat that may influence carrying capacity, or a combination of both.

Dolly Varden in the GSA and ISR are collaboratively managed by the Gwich'in Renewable Resources Board, Fisheries Joint Management Committee (FJMC), Fisheries and Oceans Canada (DFO) and Parks Canada (PC) where the broad-scale strategies, objectives and measures, and the management process are outlined in an Integrated Fisheries Management Plan (IFMP) which was formally implemented in 2010. For Dolly Varden stocks in the ISR, the West Side Working Group (whose membership consists of representatives from the Aklavik Hunters and Trappers Committee (HTC), Aklavik Elders Committee, FJMC, DFO, PC and Yukon Territorial Parks) evaluates scientific research and traditional knowledge, consults with the community of Aklavik on matters relating to Dolly Varden, and provides advice and recommendations to the IFMP Steering Committee.

Recent population studies and coastal harvest monitoring activities (including abundance estimates, the collection of catch information and biological data, and tissue samples for genetic analysis) allow for a more comprehensive assessment of the stock. The Aklavik HTC has requested a limited harvest of Dolly Varden from the Big Fish River. As a result, DFO Fisheries Management has requested science advice

Canada

on the current stock status. Data from research conducted on Dolly Varden from the Big Fish River and the Beaufort Sea coast between 2009 and 2011 were compared to data from prior years and used to assess the population. The science advice will be used to inform co-management partners on the status of Dolly Varden from the Big Fish River and the current estimated level of harvest.

This Science Advisory Report was developed following a meeting held February 29, 2012 to consider the aassessment of and recommended sustainable harvest level for Dolly Varden from the Big Fish River, NT. Additional publications from this process will be posted as they become available on the DFO Science Advisory Schedule at www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

SUMMARY

- Based on mark-recapture studies, the estimated population abundance of Dolly Varden ≥365 mm from the Big Fish River was 3,853 in 2009 and 4,338 in 2010.
- The count of Dolly Varden ≥365 mm from the Big Fish River using a DIDSON sonar was estimated to be 1,243 in 2010.
- Estimates of effective population size determined using genetic data suggest there are no immediate conservation concerns for the population.
- Using the effective population size results, abundances were estimated to be 2,336 and 2,550.
- Population abundance estimates in 2009 and 2010 remain lower compared to the 1970s, but are comparable to estimates from the 1990s.
- Biological data from the mark-recapture studies indicate a high incidence of consecutive year spawning.
- Current mean and modal length of Dolly Varden are similar to those after the population decline in the 1970s, while the proportion of fish ≥550 mm was greater during 2009-2011.
- Genetic mixed-stock fishery analysis of samples collected along the Beaufort Sea coast in 2011 indicate that Dolly Varden from the Big Fish River only contributed to the harvest at Shingle Point and King Point.
- Dolly Varden from the Big Fish River contributed 13% to the harvest at Shingle Point and King Point.
- It is estimated that the overall harvest rate of Dolly Varden from the Big Fish River in 2011 was approximately 0.75%.
- The population appears stable although the impact of an increase in fishing mortality on population abundance is uncertain.
- Continued sampling of the coastal mixed-stock fishery and implementation of a monitoring program are recommended if there is an increase in harvest for Dolly Varden from the Big Fish River.

INTRODUCTION

Dolly Varden (*Salvelinus malma*) populations with anadromous life histories have been confirmed in six river systems in the North Slope of the Yukon Territory, and in the Northwest Territories in areas west of the Mackenzie River Delta and Peel River. Among these, the Big Fish River is situated in the Richardson Mountains in the Inuvialuit Settlement Region and flows into the Mackenzie River Delta approximately 68 km northeast of Aklavik (Figure 1). Anadromous Dolly Varden from the Big Fish River is culturally important for the subsistence of Inuvialuit people, particularly for those residing in Aklavik. The population abundance of Dolly Varden from the Big Fish River declined in the early 1980s, prompting DFO in partnership with the Aklavik HTC to prohibit fishing activity in the

Big Fish River, including Little Fish River, and areas adjacent to its mouth in the Mackenzie River Delta in 1987 in order to protect the stock. The reason for the decline is unclear, however it is hypothesized that either harvest levels were too high, the spawning/ overwintering habitat was altered due to earthquake activity resulting in reduced water flows and loss of pools used by Dolly Varden to overwinter, or a combination of both. Since the closure in 1987, apart from periodic fisheries at the mouth and spawning/overwintering area that harvested a relatively small number, Dolly Varden from the Big Fish River are only harvested along the Beaufort Sea coast during the summer. Population assessments in 1987 and 2003 found no indication of improvement in population status following the decline.

Between 2009 and 2011 information on abundance and biological characteristics of the population, and the current level of fishing mortality were collected in order to update the population status of anadromous Dolly Varden from the Big Fish River. Specifically,

- mark-recapture was used to estimate population abundance;
- counts of Dolly Varden were made using a Dual Frequency Identification Sonar (DIDSON);
- adipose tissue samples were taken in order to use genetic methods to investigate effective population size (N_E) and calculate another measure of abundance;
- biological characteristics from live-sampled Dolly Varden captured and recaptured at the spawning/ overwintering area provided demographic and life history information;
- and, harvest data in combination with tissue samples collected from multiple locations along the Beaufort Sea coast were used to examine the genetic mixed-stock fishery and estimate the current harvest rate.

ASSESSMENT

Population Abundance

Population abundance estimates were undertaken by capturing (tagging) and/or recapturing a sample of Dolly Varden in the fall (late September) at the spawning/ overwintering area of Little Fish River in 2009, 2010 and 2011. The Petersen model with Chapman modifier was used to estimate population size with 95% confidence intervals calculated based on the assumption that the probability of recapture followed a Poisson distribution. The Poisson approximation was used because the number of recaptures between years was consistently <50, and the ratio between number of recaptures and number of tagged was <0.1 (Seber 1982). To better meet the assumptions required to use the Petersen model, corrections were made to account for recruitment and tag loss.

The population abundance for Dolly Varden ≥365 mm in length from the Big Fish River was 3,853 (95% Confidence Interval (CI)I= 2,758 - 6,497) in 2009 and 4,338 (95% CI= 3,084 - 7,265) in 2010. The current population size is considerably lower compared to the early 1970s yet remains similar to multiple abundance estimates periodically determined in the 1990s, which suggests that the population abundance has remained stable over the past approximately 20 years (Figure 2).

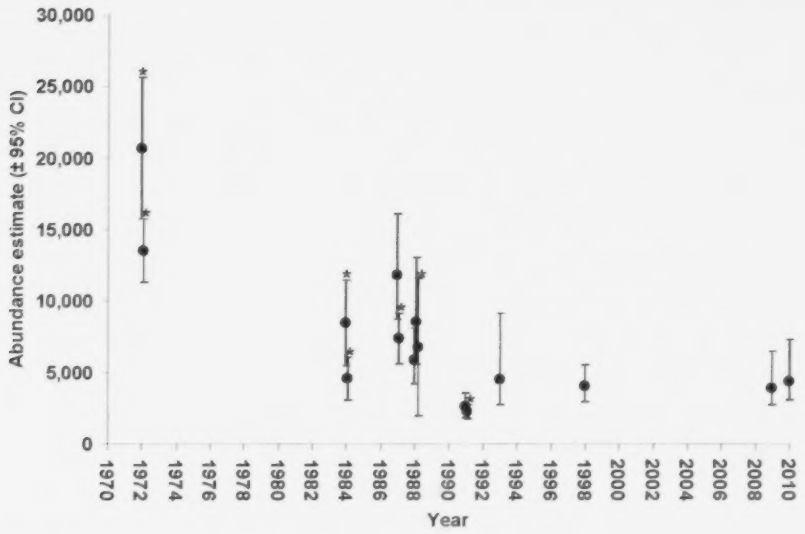

Figure 2. Population abundances of Dolly Varden from the Big Fish River among years estimated periodically between 1972 and 2010. The 95% confidence intervals were calculated based on the probability of recaptures following a Poisson distribution while years where recaptures were >50 the intervals were calculated based on the normal distribution (*).

Counts of Fish

The DIDSON is a multibeam sonar designed to be used in turbid or low-light conditions. It transmits high frequency pulses of sound in the water and converts the returning echo into digital images. The Long-Range (L-R) model of the DIDSON was used to enumerate the upstream movements and record the length of fish in Little Fish River between August 6 and September 13, 2010 with the objective of estimating the number of migrating Dolly Varden. The images produced by the DIDSON did not provide the resolution to distinguish among species of fish (assumed to be predominantly Dolly Varden and Arctic Grayling). A weir study conducted in Little Fish River in 1991 demonstrated that species other than Dolly Varden accounted for 9.4% of the fish encountered by the weir. Arctic grayling in the Little Fish River generally do not attain lengths >400 mm, therefore, in order to account for species other than Dolly Varden the 9.4% value derived in 1991 was applied to the total number of fish <400 mm enumerated using the DIDSON.

After subtracting fish moving downstream from ones moving upstream and accounting for other species, the estimated number of Dolly Varden ≥365 mm in length enumerated by the DIDSON was 1,243. Shortly after the deployment of the camera, increased water levels and flow rates in the river rendered the camera inoperable for just over two days. Soon after, the number of fish moving upstream peaked on August 19, 2010 (n= 404), followed by a precipitous drop in abundance and an increase in water level. Counts of fish gradually increased as water levels in the river decreased, indicating that upstream movements of fish were possibly negatively correlated with discharge at the location where the sonar was deployed. Counts of fish leveled off at approximately 50 per day from September 1 to 13. The entire upstream migration of Dolly Varden was not enumerated and this, in combination with periods when the camera was not operational due to water conditions and the challenge of distinguishing among species, limited the use of the data in obtaining an accurate indication of population size and comparison with results from the mark-recapture study.

Effective Population Size

The effective size of a population (N_E) determines the rate at which genetic variability will be lost as a result of random genetic drift (the random change in allele/genotype variants across generations) and is a parameter that is typically less than the census population size (N_C). Decreases in N_E lead to decreases in genetic variation, increases in inbreeding and reductions in overall fitness. Therefore reductions in N_E may potentially have several adverse impacts on a population, especially those that are already small and isolated. Given that genetic variation is important for evolutionary potential, N_E should also be considered when evaluating the long-term plans for population persistence and conserving biological diversity within a species.

To estimate N_E using genetic data, a temporal approach was used whereby samples from two separate sampling periods at least one generation apart (1994 and 2009) were analyzed. For the estimation of N_E in Dolly Varden from the Big Fish River, two independent temporal methods (MLNE version 1.1: Wang 2001, TM3: Berthier et al. 2002) were applied to a microsatellite DNA data set. Using these two approaches, N_E was estimated to be 327 (95% CI= 210-565; TM3 method) and 357 (95% CI= 241-615; MLNE method). Employing a ratio for N_E/N_C of 0.14 (Palstra and Ruzzante 2008), it is possible to estimate population size. Accordingly, this results in census population size estimates of 2,336 (95% CI= 1,500 – 4,035; TM3 method) and 2,550 (95% CI= 1,721 – 4,393; MLNE method). Our estimates of N_E suggest that there are no immediate conservation concerns (e.g., reductions in fitness as a result of inbreeding) for Dolly Varden from the Big Fish River and long-term population persistence is likely if effective population size remains the same.

Biological Characteristics

Dolly Varden were live-sampled at the Big Fish River spawning/overwintering area using a seine net at the end of September in 2009, 2010 and 2011. Each fish captured in the net was identified to species and measured for fork length (± 5 mm). The life history type (anadromous or resident) was identified and, for all anadromous fish, the reproductive status was recorded ('non-spawner' or 'spawner') along with the sex if it was in spawning condition.

Females begin to mature after 345 mm fork length, and the majority were mature by the time they reached 450 mm (Figure 3). The length-at-50%-maturity for females was 421 mm (2009-2011 samples combined and based on a logistic model). Relatively few females from the Big Fish River attain sizes ≥550 mm. Similar to females, males begin to mature around 360 mm and reach 50% maturity at 479 mm (2009-2011 samples combined). A relatively higher proportion of males attained sizes ≥550 mm compared to females (Figure 3).

The mean and modal values of length from 2009-2011 were similar to those observed after the population decline in the 1980s (Figure 4). Results from 2009-2011 indicate a higher proportion of large-size males (≥550 mm) in the population compared to earlier years while the proportion of large size females (≥500 mm) in 2009-2001 appears similar to values from the 1990s, which are higher than those from the 1980s (Figure 5).

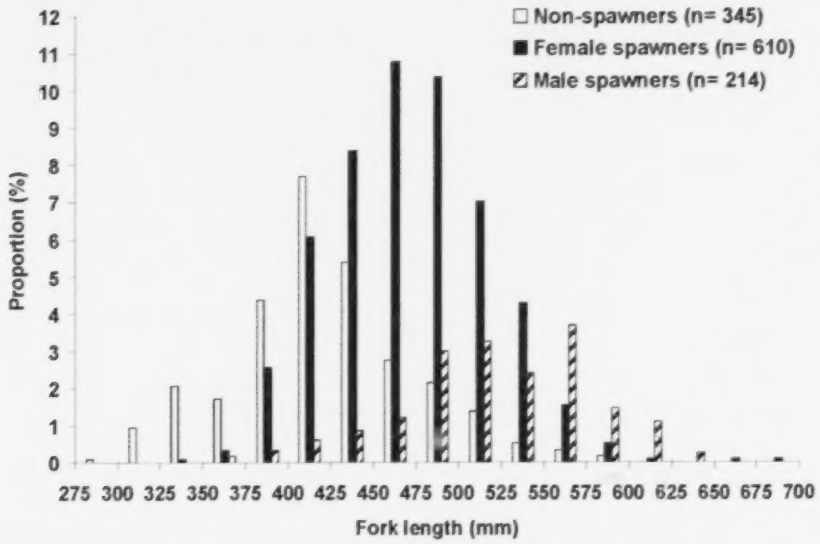

Figure 3. Fork length frequency distribution of Dolly Varden from the Big Fish River captured by seine at the spawning/ overwintering area in 2009, 2010 and 2011 (all years combined).

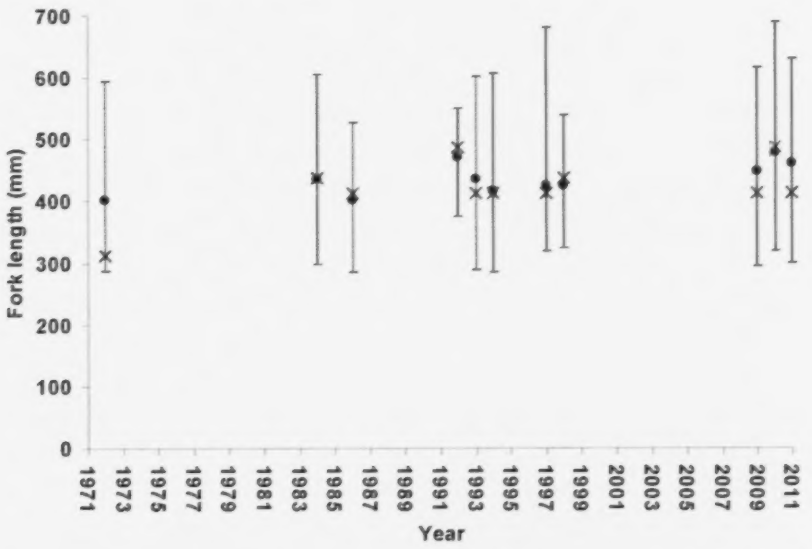

Figure 4. Mean (•), mode (X), minimum and maximum (bars) fork length of Dolly Varden from the Big Fish River captured by seine at the spawning/ overwintering area periodically between 1972 and 2011.

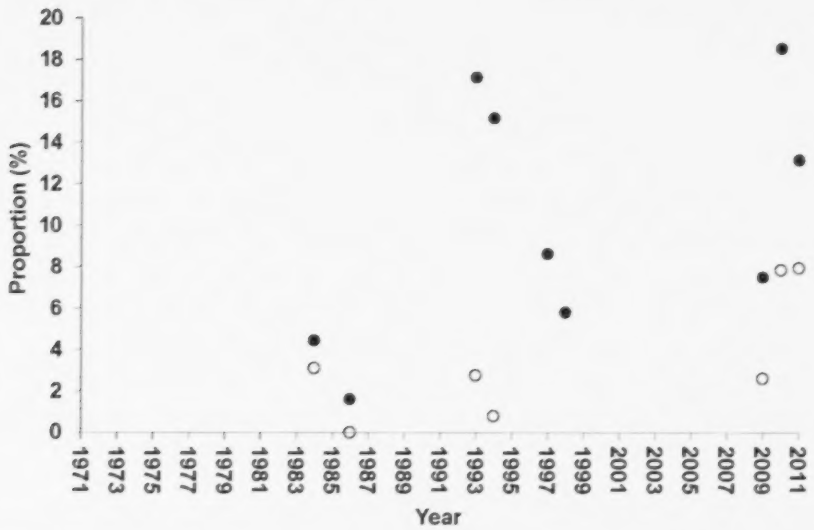

Figure 5. Proportion of female ≥500 mm (●) and male ≥550 mm (○) Dolly Varden from the Big Fish River captured by seine at the spawning/overwintering area periodically between 1972 and 2011. Note that the data for males in 1997 and 1998 are omitted because males were selectively removed from the dead-sample at the sampling site.

Based on recaptures of tagged Dolly Varden, the annual change in growth was greater for males than females, indicating that males have a higher growth rate which provides some explanation for the higher proportion of males among larger size classes. When annual changes in growth based on tag returns were compared between 1987-1988 and 2009-2011, no significant differences were detected. This indicates that density dependent effects or environmental conditions have had no effect on growth rate and that the current presence of larger-sized fish is not related to an increase in growth rate since the late 1980s.

The annual maturity cycle of Dolly Varden from the Big Fish River was inferred based on tag recapture information (2009-2011). The majority of male (n= 7) and female (n= 20) Dolly Varden were in spawning condition both years when captured in consecutive years. In certain instances, males (n= 4) and females (n= 8) were tagged as non-spawners and recaptured as spawners the following year. Based on the length information, these Dolly Varden were likely immature when tagged and first time spawners when recaptured. These results, combined with the observation that there has not been any instance where a spawner was recaptured the following year as a non-spawner, indicate that the reproductive strategy for female and male Dolly Varden from the Big Fish River is consecutive year spawning.

Anadromous females in spawning condition (range: 46.3 - 56.9% of the total sample for a particular year) were more abundant than anadromous males in spawning condition (range: 13.0 - 20.4% of the total sample for a particular year) in samples taken between 2009 and 2011. The majority of Dolly Varden sampled at the spawning/ overwintering area were in spawning condition (range: 59.3 - 77.7% of the total sample for a particular year), which suggest high reproductive potential for the population or non-spawners may occupy different unknown regions of river at time of survey.

Coastal Harvest

Harvest statistics for Dolly Varden along the Beaufort Sea coast in the Yukon were collected by Yukon Territorial Parks (Herschel Island), and reported to the Aklavik HTC (Ptarmigan Bay, Phillips Bay, King Point and Shingle Point) (Figure 1). One of the most important harvesting locations for Dolly Varden is Shingle Point, where there have been periodic monitoring programs in place to obtain more accurate harvest numbers. In 2011, a comprehensive monitoring program was established for multiple locations along the coast to obtain total harvest information and collect biological data which included fin clip samples for genetic mixed-stock fishery analysis (Table 1). A total of 458 Dolly Varden were harvested along the coast in 2011 and a large majority of these were sampled.

Table 1. Harvest statistics for Dolly Varden from multiple locations along the Beaufort Sea coast in the Yukon 2009-2011.

	Herschel Island	Ptarmigan Bay	Phillips Bay	King Point	Shingle Point
2011	129	93	0	43	193
2010	256	-	-	-	252*
2009	80	6*	2*	-	307*

* = reported harvest values.
- = unreported harvest.

Genetic mixed-stock analysis

Genetic techniques were used to examine the mixed-stock subsistence fishery along the Beaufort Sea coast during the summer to determine the contribution of Dolly Varden from the Big Fish River at these locations. These results, in combination with total harvest information, provided data to estimate the harvest of Dolly Varden from the Big Fish River. Coastal samples were analyzed against an established genetic baseline comprised of all known anadromous Canadian Dolly Varden stocks and a subset of Alaskan stocks from the North Slope. Alaskan stocks were included in these analyses as they have been previously reported to contribute to Canadian coastal fishing sites (Krueger et al. 1999). For the purpose of this study, Alaskan Dolly Varden stocks were pooled with the Firth River system to represent a single stock. Fifteen microsatellite DNA markers were assayed from tissue samples collected in 2011 from Herschel Island (n= 84), Ptarmigan Bay (n= 90), King Point (n= 22) and Shingle Point (n= 167). Samples from King Point and Shingle Point were combined since harvesters from Shingle Point periodically made day trips to King Point to harvest a relatively small number of fish. Genetic mixed-stock analysis of the Dolly Varden from each coastal fishing site was performed to determine the genetic mix of the fish caught in these fisheries. A conditional maximum likelihood procedure implemented in the genetic stock identification program ONCOR (Kalinowski et al. 2007) was used to report contributions from each Dolly Varden source stock to each coastal fishing site. Simulation and assignment tests verified the accuracy and confirmed the results from the mixed-stock analysis.

The results for 2011 indicate that Dolly Varden from the Big Fish River did not contribute to the harvest at Herschel Island and Ptarmigan Bay. The Big Fish River stock was only detected at Shingle/King Point, which contributed 13.2% (95% CI= 8.9 - 18.5%) to the total harvest. Using the harvest data from Shingle and King Point, it is estimated that 31 of the 236 Dolly Varden collectively captured at both locations in 2011 were from the Big Fish River stock. The rate of harvest in 2011 was approximately 0.75% (95% CI=0.5% -1.0%), based on averaging the 2009 and 2010 population estimates from mark-recapture (~4,096) and incorporating the 31 Dolly Varden from the Big Fish

River harvested in 2011. The IFMP for Dolly Varden states that a harvest rate of 5% is safe for stocks considered healthy.

Sources of Uncertainty

- There is some uncertainty whether all the assumptions of the Petersen method are sufficiently met in order to achieve a suitable estimate of population size.
- It is uncertain whether a portion of the migrating population of fish were missed prior to the deployment of the DIDSON camera on August 6, 2010 and how many fish were missed after the camera was removed on September 13, 2010.
- The accuracy of N_E estimates is largely reliant on the quality and variability of genetic data that are available.
- The true ratio of N_E/N_C is not known for northern form Dolly Varden and estimates of N_C produced from our estimate of N_E are based on ratios published in the literature
- Subsistence fisheries in coastal regions may be inconsistent with regards to the effort made, time invested, and the location that the fishing is done and therefore may not be representative of the coastal run. These variables contribute to composition discrepancies seen over seasonal and annual timeframes. One year of data is not sufficient to understand the spatio-temporal variation of these mixed-stock fisheries.

CONCLUSIONS AND ADVICE

1) The Petersen (with the Chapman Modifier) mark-recapture population estimate of Big Fish River Dolly Varden, ≥365 mm was 3,853 (95% CI=2,758-6,497) in 2009, and 4,338 (95% CI=3,084-7,265) in 2010. A Poisson distribution was used to calculate the 95% CI.

2) The DIDSON count for Dolly Varden ≥365 mm was estimated to be 1,243 in 2010. However, there are limitations that could affect the accuracy of the count; including the timing and length of camera deployment, periods of time when the camera could not be operated due to water conditions and the challenge of distinguishing among species.

3) Further comparative work between mark-recapture and DIDSON counts are required to evaluate the accuracy and effectiveness of the DIDSON for Dolly Varden in these systems.

4) The effective population size suggests there are no immediate conservation concerns for the Big Fish River population. Employing an *Ne*/*Nc* ratio of 0.14 and using two different methods, census population estimates of 2,336 (95% CI=1,500-4,035) and 2,550 (95% CI=1,721-4393) were produced.

5) The population estimates in 2009 and 2010 remain considerably lower than those estimated in the 1970s (prior to population decline and closure), but are comparable to estimates from the 1990s.

6) Tagging and length/maturity data suggest a high incidence of consecutive year spawning.

7) Mean and modal values of length are similar to those observed after the population decline. Growth between 1987 and 1988 and present has also not changed. However, the proportion of fish ≥550 mm was greater during 2009-2011. These results suggest no density dependent or other effects on growth, but more likely a positive response to reduced harvest.

8) In 2011, reported harvest level of Dolly Varden in the Yukon coastal fisheries, from all stocks, was 458.

9) Results from genetic mixed-stock analysis of the combined Shingle Point and King Point coastal fisheries, sampled throughout the fishery in 2011, indicate that the sample was comprised of approximately 13% (95% CI= 9%-18%) Big Fish River stock, or 31 of the 236 Dolly Varden collectively caught at Shingle Point and King Point were fish from the Big Fish River stock. There was no contribution from the Big Fish River stock to Ptarmigan Bay and Herschel Island, the other coastal fisheries sampled in 2011.

10) There can be considerable temporal variability in the proportion of contributing source stocks present in a mixed fishery, on a seasonal and annual basis. It is recommended that genetic samples continue to be collected from Dolly Varden caught in the coastal fisheries in order to improve the understanding of the extent of stock mixing in these fisheries.

11) Based on the mixed-stock fishery analysis and the population estimates given above, the estimated harvest rate for Big Fish River Dolly Varden was approximately 0.75% (95% CI=0.5% -1.0%) for 2011.

12) Big Fish River Dolly Varden size structure (e.g., recent increases in the number of fish >550 mm) indicates that there have been no year class failures and the population appears to be stable. However, abundance estimates remain at levels lower than those reported prior to 1989. The impact of an increase in fishing mortality on population abundance is uncertain.

13) Given the relatively low abundance and in the interest of protecting a relatively small population, a precautionary approach for management of Big Fish River Dolly Varden should suggest a conservative harvest. If an increase in harvest is considered it should be accompanied by a comprehensive monitoring program including both fishery dependent and independent sampling.

SOURCES OF INFORMATION

This Science Advisory Report was developed following a meeting held February 29, 2012 to consider the assessment of and recommended sustainable harvest level for Dolly Varden from the Big Fish River, NT. Additional publications from this process will be posted as they become available on the Fisheries and Oceans Canada Science Advisory Schedule at www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

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FOR MORE INFORMATION

Contact: Colin Gallagher
Fisheries and Oceans Canada
501 University Crescent
Winnipeg, Manitoba
R3T 2N6

Tel: (204) 983-8893
Fax: (204) 984-2403
E-Mail: Colin.Gallgher@dfo-mpo.gc.ca

This report is available from the:

Centre for Science Advice (CSA)
Central and Arctic Region
Fisheries and Oceans Canada
501 University Crescent
Winnipeg, MB
R3T 2N6
Telephone: (204) 983-5131
E-Mail: xcna-csa-cas@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas-sccs

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